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MR T1ρ AND T2 OF MENISCUS SIX MONTHS AND ONE YEAR AFTER ACUTE ANTERIOR CRUCIATE LIGAMENT INJURY

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Purpose: Acute anterior cruciate ligament (ACL) injury, a high-risk factor for post-traumatic osteoarthritis, is often concomitant with meniscal lesions and tears. In our previous cross-sectional study, we found that acute ACL injuries were associated with significantly elevated meniscal T1ρ and T2 values compared to healthy knees, even in menisci without morphological signs of damage. The goal of this longitudinal study was to evaluate intermediate-term changes in meniscal T1ρ and T2 quantification in ACL-injured patients six months and one year after ACL reconstruction and to compare these changes to baseline results.
Methods: Using a 3T MR scanner, a closed cohort of 39 patients (age = 29.4 ± 7.5 years; 16 females) with acute ACL injuries was scanned at an average of 8.4 ± 6.4 weeks post-injury and prior to ACL reconstruction. After ACL reconstruction, follow-up scans of ACL-injured knees were completed at six months and one year after baseline scan. Subjects were categorized by no lateral meniscectomy (n = 32) and partial lateral meniscectomy (n = 7). Effects of medial meniscectomy were not evaluated due to small sample size (n = 2).
Imaging protocol included sagittal T2-weighted 3D fast spin-echo (CUBE) images [repetition time (TR)/echo time (TE) = 1500/25 ms, field of view (FOV) = 16 cm, matrix = 384 x 384, slice thickness = 1 mm, echo train length = 50, bandwidth = 50 kHz, number of excitations = 0.5] and sagittal 3D T1ρ and T2 quantification sequences [TR/TE = 9 ms/min full, FOV = 14 cm, matrix = 256 x 128, slice thickness = 4 mm, Views Per Segment = 64, time of recovery = 1.2 s, spin-lock frequency = 500 Hz, ARC phase AF = 2. TSL = 0/10/40/80 ms for T1ρ, and preparation TE = 0/13.7/27.3/54.7 ms for T2]. Menisci were segmented using CUBE images into four sub-compartments: anterior horn of the lateral/medial meniscus (AHLAT/AHMED) and the posterior horn of the lateral/medial meniscus (PHLAT/PHMED). These regions of interest (ROI) were overlaid onto T1ρ and T2 maps, and mean T1ρ and T2 values were calculated for each ROI. Paired t-tests were performed when comparing the same cohort at different time points, and unpaired t-tests were performed when comparing patients who had a partial meniscectomy and patients who did not have a meniscectomy. An alpha of less than 0.05 was considered significant.
Results: In ACL-injured knees without meniscectomy, T1ρ values increased significantly from baseline to six months in the AHLAT, AHMED, and PHMED (all $p < 0.01$), while T2 values increased significantly in the AHMED ($p = 0.002$). From six months to one year, T1ρ values decreased significantly in the AHMED and PHMED (both $p = 0.001$), while T2 values decreased significantly in the PHMED ($p = 0.02$). No significant differences were found when comparing T1ρ and T2 values from baseline to one year. In ACL-injured knees that had undergone partial lateral meniscectomy, no significant differences in T1ρ or T2 values were found between the baseline, six-month, and one-year scans.
Before ACL reconstruction, baseline data showed significantly higher T2 values in the PHLAT of patients who later underwent a partial lateral meniscectomy compared to patients who did not undergo lateral meniscectomy ($p = 0.03$). However, after reconstructive surgery, at six months and one year, no significant differences in T1ρ or T2 values were found between knees with partial lateral meniscectomy and knees without lateral meniscectomy.
Conclusions: This longitudinal study found that elevated meniscal T1ρ and T2 values of ACL-injured knees without meniscectomy continued to increase in the subsequent six months before decreasing at one year after the initial scan, whereas elevated T1ρ and T2 values of ACL-injured knees with partial lateral meniscectomy remained constant. The consistency between baseline and one-year data in both knees with and without meniscectomy suggests the following possibilities: (1) little to no healing of the initial damage in the meniscus had occurred by one year, (2) the meniscal collagen-proteoglycan matrix is undergoing early degeneration processes by one year, resulting in sustained elevated T1ρ and T2 values, or (3) a combination of both. The loss of significant difference in T2 values after reconstructive surgery between knees with and without partial lateral meniscectomy indicate that quantitative T2 has the potential to reflect the effects of partial meniscectomy. We are currently following up on these patients at two years and three years to evaluate long-term changes of the meniscus after ACL injury and reconstruction.
Acknowledgments:
This study was supported by NIH/NIAMS P50 AR060752.

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ASSOCIATIONS BETWEEN KNEE PAIN AND SYNOVITIS ON CONVENTIONAL AND DYNAMIC CONTRAST-ENHANCED MAGNETIC RESONANCE IMAGING IN OBESE PERSONS WITH KNEE OSTEOARTHRITIS: A CROSS-SECTIONAL STUDY

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Purpose: To investigate the association between knee pain and synovitis in obese persons with knee osteoarthritis (OA).
Methods: In a cross-sectional setting, knee synovitis was assessed using 3-tesla magnetic resonance images (MRI) and correlated to self-reported outcomes using the Knee injury and Osteoarthritis Outcome Score (KOOS).
Synovitis was assessed: i) in the suprapatellar, lateral and medial recesses using dynamic contrast-enhanced (DCE) MRI and collapsed into one volume of interest (VOI), and ii) semi-quantitavely in 11 eleven locations using contrast-enhanced (CE) MRI generating a whole-knee synovitis score. Effusion was assessed on CE-MRI according to the Boston-Leeds OA Knee Score (BLOKS) and the combination of synovitis and effusion was scored on non CE-MRI using the MRI in OA Knee Score (MOAKS). In a voxel-by-voxel approach, the following DCE-MRI variables were automatically extracted from the VOI: i) the Initial Rate of Enhancement (IRE), i.e. the mean speed of enhancement, ii) Maximal Enhancement (ME), i.e. the mean of the highest signal intensity values and iii) Nvoxel, the sum of voxels with plateau and washout patterns, i.e. the most perfused voxels.
The DCE-MRI variable IRExNvoxel was chosen as the primary variable in the analyses.
Results: Valid MRI and clinical data were available in 94 persons. The typical participant was a 65-year old woman with a mean body mass index of 32.3 kg/m^2, a Kellgren-Lawrence score of 2.5 and a C-reactive protein level of 2.0 mg/l.
The DCE-MRI variable IRExNvoxel showed a statically significant bivariate correlation with KOOS pain ($r = -0.34$; $p=0.001$) and all the remaining KOOS items ($-0.25 > r > -0.46$; $p<0.007$) as was the case with the whole-knee synovitis score (Table 1).
The non CE-MRI variable MOAKS effusion-synovitis showed statistically significant correlation with 3 of the 5 KOOS items ($-0.29 > r > -0.30$; $p<0.005$).
Intraclass correlation coefficients ranged between 0.95-1.00 for the DCE-MRI variables and 0.80-1.00 for the static MRI variables.
Conclusions: The results confirm an association between pain and synovitis assessed on both DCE- and CE-MRI in obese patients with knee OA. The whole-knee synovitis score on CE-MRI and most of the DCE-MRI variables were also significantly associated with the remaining KOOS items.
DCE-MRI analyses were robust and highly reproducible and have the potential to be used to further investigate the role of inflammation and perfusion in knee OA, in a similar way it has been used in inflammatory joint diseases.

Table 1
Correlation matrix of KOOS and MRI variables.

	Nvoxel	Nvoxel_Rel	MExNvoxel	IRExNvoxel	IRExME	CE_Synovit	BLOKS_Effusion	MOAKS_Effusion
Nvoxel	1.000							
Nvoxel_Rel	.499** (p<0.0001)	1.000						
MExNvoxel	.985** (p<0.0001)	.508** (p<0.0001)	1.000					
IRExNvoxel	.948** (p<0.0001)	.556** (p<0.0001)	.978** (p<0.0001)	1.000				
IRExME	.815** (p<0.0001)	.554** (p<0.0001)	.884** (p<0.0001)	.950** (p<0.0001)	1.000			
CE_Synovit	.794** (p<0.0001)	.408** (p<0.0001)	.823** (p<0.0001)	.808** (p<0.0001)	.769** (p<0.0001)	1.000		
BLOKS_ Effusion	.676** (p<0.0001)	.182 (p=0.080)	.682** (p<0.0001)	.659** (p<0.0001)	.566** (p<0.0001)	.474** (p<0.0001)	1.000	
MOAKS_ Effusion	.803** (p<0.0001)	.242* (p=0.019)	.802** (p<0.0001)	.772** (p<0.0001)	.673** (p<0.0001)	.592** (p<0.0001)	.824** (p<0.0001)	1.000
KOOS_Pain	-.270** (p=0.008)	-.167 (p=0.110)	-.323** (p=0.002)	-.337** (p=0.0009)	-.370** (p=0.0002)	-.355** (p=0.0004)	-.212* (p=0.04)	-.294** (p=0.004)
KOOS_Symp	-.381** (p=0.0002)	-.177 (p=0.088)	-.428** (p<0.0001)	-.463** (p<0.0001)	-.471** (p<0.0001)	-.386** (p=0.0001)	-.330** (p=0.001)	-.290** (p=0.005)
KOOS_ADL	-.200 (p=0.053)	-.200 (p=0.053)	-.243* (p=0.018)	-.252* (p=0.014)	-.278** (p=0.007)	-.278** (p=0.007)	-.117 (p=0.262)	-.173 (p=0.095)
KOOS_QOL	-.313** (p=0.002)	-.271** (p=0.008)	-.362** (p=0.0003)	-.392** (p<0.0001)	-.423** (p<0.0001)	-.356** (p=0.0004)	-.189 (p=0.068)	-.298** (p=0.003)
KOOS_ SportRec	-.228* (p=0.027)	-.236* (p=0.022)	-.278** (p=0.007)	-.289** (p=0.005)	-.320** (p=0.002)	-.307** (p=0.003)	-.127 (p=0.068)	-.127 (p=0.222)

Spearman's rho with p-values in parentheses.
**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).
Nvoxel: Sum of voxels with plateau and washout enhancement patterns. Nvoxel_Rel: Nvoxel over the total number of enhancing voxels. IRE: Initial rate of enhancement; ME: Maximal enhancement; CE_Synovitis: Whole-knee synovitis score (on CE-MRI); BLOKS_Effusion: Boston-Leeds OA Knee Score effusion score (CE-MRI); MOAKS_Effusion: MRI in OA Knee Score effusion-synovitis score (non CE-MRI); KOOS: Knee injury and OA Outcome Score; Symp: Symptoms; ADL: Activity in Daily Living; QOL: Quality of Life; SportRec: Sport/Recreation.

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ANATOMICAL ALIGNMENT, BUT NOT GONIOMETRY, PREDICTS FEMOROTIBIAL CARTILAGE LOSS AS WELL AS MECHANICAL ALIGNMENT

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Purpose: Frontal plane lower limb alignment has important associations with the distribution of load in the femorotibial joint and with the location and magnitude of structural progression of knee osteoarthritis (OA). Alignment is conventionally determined as the mechanical axis (or hip-knee-ankle [HKA]) angle from full limb radiographs. Yet, other, simpler measures of frontal plane alignment exist, including a new method for measuring the anatomical axis (or femorotibial angle [FTA]) from fixed flexion radiographs, aligned with measures of radiographic joint space. However, it is unclear how this measure, or non-radiographic goniometry, predict cartilage thickness loss as measured quantitatively with MRI in relation to HKA. The objective of the current study was hence to identify how this new FTA measure and goniometry predict medial and lateral cartilage thickness loss from MRI compared with the HKA gold standard.
Methods: Participants were selected from the Osteoarthritis Initiative (OAI). 450 knees were available with baseline and 1-year follow-up MRI measurements (coronal FLASH acquisitions) and 489 with baseline and 2-year follow-up MRI (sagittal DESS). Knees with incomplete measures of frontal plane alignment or with Kellgren and Lawrence grade <2 (no definite radiographic OA) were excluded. Progression was defined as cartilage thickness loss exceeding the smallest detectable change (SDC) in the medial (MFTC: -102μm [FLASH], -111μm [DESS]) or lateral femorotibial compartment (LFTC: -92μm [FLASH], -121μm [DESS]), respectively. HKA, FTA and goniometer measures were categorized into (a) neutral, (b) varus and (c) valgus. Neutral HKA and goniometer angles were defined as -2° to 2°. Based on a previously determined offset across all OAI participants with FTA and HKA measurements, a neutral FTA was defined as -6.3° to -2.3°. Correlations between cartilage loss and alignment measures were determined by calculating Pearson coefficients. Logistic regression models were used to determine the odds of medial and lateral progression in varus and valgus knees, measured by each alignment method, and using neutral knees as a reference. All models were adjusted for age, sex and body mass index.
Results: Correlations of MFTC/LFTC cartilage thickness loss between baseline and 1-year follow-up were largest for HKA (r=0.21/-0.19) and somewhat lower for FTA (r=0.15/-0.13) and goniometry (r=0.12/-0.11). Correlations of cartilage loss between baseline and 2-year follow-up were similar for HKA (r=0.28/-0.29) and FTA (r=0.28/-0.30) and lower for goniometry (r=0.11/-0.16). When applying the 4.3° valgus offset to the 1-year follow-up cohort, the new FTA alignment measure predicted MFTC progression (adjOR=3.05) and LFTC progression (adjOR=2.67) as well as the HKA gold standard (adjOR=3.17 and 2.31, respectively, Table 1). Without using the offset, the prediction by the new measurement was less strong. In the 2-year follow-up cohort, FTA appeared to be a better predictor for MFTC progression (adjOR=2.44) and LFTC progression (adjOR=3.40) than the HKA gold standard (adjOR = 1.66 and 2.24, respectively, Figure 1). Without using the FTA offset, the new measurement was a good predictor of MFTC progression (adjOR=4.09), but not LFTC progression. Goniometry was a weak predictor for MFTC and LFTC progression in both cohorts (Table 1; Figure 1).
Conclusions: Compared to the gold standard of measuring mechanical alignment using full limb radiographs (HKA), the new FTA measurement was at least as good in predicting MFTC/LFTC cartilage thickness loss when

Table 1
Adjusted odds ratios and 95% confidence intervals for measures of alignment predicting MFTC/LFTC progressors and non-progressors from baseline to 1-year follow-up.

Alignment	MFTC			LFTC		
	adjOR	95%CI	p	adjOR	95%CI	p
HKA	3.17	1.80, 5.58	<0.001	2.31	1.22, 4.35	0.010
FTA (with offset)	3.05	1.83, 5.89	<0.001	2.67	1.38, 5.17	0.003
FTA (without offset)	2.17	0.88, 5.31	0.091	0.64	0.11, 3.77	0.626
Goniometer	1.65	0.90, 3.03	0.108	1.71	1.01, 2.90	0.045